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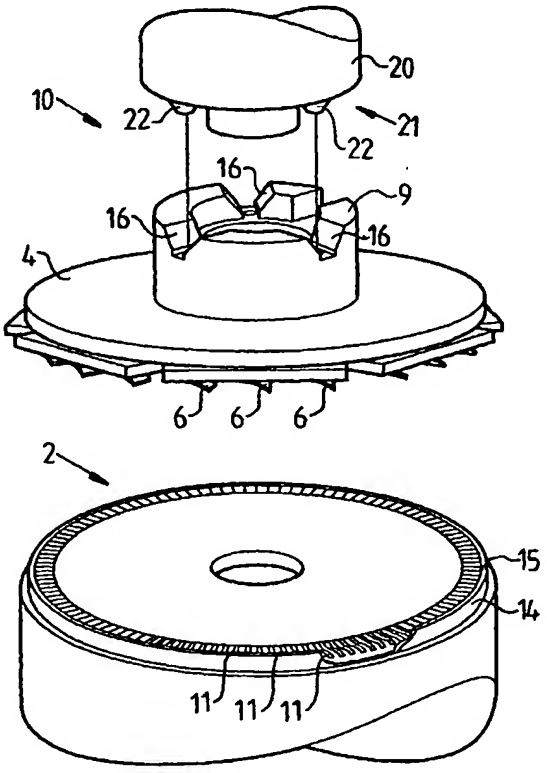
(54) Title: A METHOD AND A DEVICE FOR MANUFACTURING A STATOR COMPONENT OR ROTOR COMPONENT



(57) Abstract: The invention relates to a method for manufacturing a disk-shaped or annular stator component or rotor component with a plurality of blades arranged one after another in a path extending around said component and a cover (15) arranged outside the blades in the radial direction and in contact therewith. According to the method, at least a portion (11) of a first set of channels (12) is electro discharge machined simultaneously out of a disk-shaped or annular workpiece (2) intended for forming the component at a distance from the edge (14) of the workpiece in the radial direction, which channels (12) are intended to delimit said blades in the circumferential direction of the workpiece.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A method and a device for manufacturing a stator component or rotor component

FIELD OF THE INVENTION

The present invention relates to a method for manufacturing a disk-shaped or annular stator component or rotor component with a plurality of blades arranged one after another in a path extending around said component for guiding a gas flow. In other words, such a component can be used in both static applications (stators) and dynamic applications (rotors). This component is commonly referred to as a "blisk" (bladed disk) or a "bling" (bladed ring). The invention also relates to a device for manufacturing said stator component or rotor component.

In the following description, the stator component or rotor component is intended to be arranged in a turbopump in a space application. Turbopump means a unit which comprises at least a turbine and a pump part driven by the latter. The invention is not to be regarded as being limited to this application but can also be used in a gas turbine. Other areas of application are also possible, such as in engines for vehicles, aircraft, power plant equipment for vessels and power stations for electricity production.

The stator component or rotor component is often designed with an annular cover outside the blades in the radial direction and in contact with these. This cover outside the blades is arranged for the purpose of counteracting leakage from a pressure side to a suction side of the blades concerned. Such leakage is associated with efficiency losses.

PRIOR ART

There are a number of different known ways of manufacturing such a stator component or rotor component. According to a previously known

manufacturing technique, each of the blades is manufactured individually. The blades are subsequently secured with a mutual spacing in a groove on the periphery of a circular disk so that they project in the radial direction from the latter. Each of the blades is often manufactured with a cover part in such a way that an essentially continuous cover is formed after the blades have been mounted on the circular disk.

It is moreover known to use electro discharge machining (EDM) in the manufacture of said stator component or rotor component. In this case, each blade is produced separately by electro discharge machining a disk-shaped or annular workpiece intended to form the component. Four electro discharge machining stages (and four different electro discharge machining electrodes) are required for manufacturing each of said blades. During EDM, half the blade is machined from a first side of the workpiece via a first and a second electro discharge machining operation on the pressure side and, respectively, the suction side of the blade. When all the blades have been machined from the first side of the workpiece, it is turned, and the remaining part of each of the blades is machined from the second side of the workpiece via a third and a fourth EDM operation.

DISCLOSURE OF THE INVENTION

One object of the invention is to provide a method for manufacturing a disk-shaped or annular stator component or rotor component which is time-efficient and cost-effective. The invention also aims to achieve a manufacturing method which creates possibilities for a component with great strength and improved efficiency.

This object is achieved by virtue of the fact that at least a portion of each of a plurality of channels in a first set of channels is electro discharge machined simultaneously out of a disk-shaped or annular

workpiece intended for forming the component, which channels are intended to delimit said blades in the circumferential direction of the workpiece.

On the whole, the manufacturing method is non-sensitive to the material to be machined. The stator component or rotor component is manufactured from a single piece, which creates possibilities for great strength, especially in combination with a material which tolerates great temperature transients, such as what is known as a superalloy. In order for it to be possible to machine a plurality of channels simultaneously, a plurality of EDM electrodes are in engagement with the workpiece simultaneously.

In such electro discharge machining, which is known per se, material is removed from the surface of the workpiece under the action of a power density which arises when short electrical discharges take place between an EDM electrode and the workpiece. Here, the EDM electrode has the shape of a negative replica of the intended shape of the channel.

According to a preferred embodiment of the invention, after EDM of said portion of the first set of channels, the workpiece is rotated through a distance in its circumferential direction, and then at least a portion of each of a plurality of channels in a second set of channels is electro discharge machined. The EDM electrodes intended for the electro discharge machining are therefore arranged at a spacing in the circumferential direction of the workpiece which is greater than the intended spacing between the channels. In other words, machining of a plurality of channels takes place simultaneously, after which the EDM means is indexed and a new set of channels can be machined out of the workpiece.

According to a development, the workpiece is turned after all the channels have been electro discharge machined from a first side of the same, and the remaining portion of the channels is then electro discharge machined in the same way from its second side. In this way, relatively complex blade shapes can also be produced.

According to another preferred embodiment, said channels are electro discharge machined at a spacing from the edge of the workpiece in the radial direction, so that a cover is formed outside the blades in the radial direction and in contact therewith. In other words, the cover is formed by the material of the workpiece remaining outside the blades in the radial direction. In this way, a continuous cover is formed, which creates possibilities for a component with great efficiency.

According to another preferred embodiment of the invention, in a first operation, a plurality of EDM electrodes are machined, with a mutual spacing along a curved path, from at least one basic element arranged on a means intended for the EDM, and, in a second operation, the channels are electro discharge machined from the workpiece by means of said EDM electrodes. The machining in the first operation preferably comprises milling. The method for manufacturing the component therefore comprises two stages, namely firstly manufacturing the tool itself which is to be used for EDM and subsequently electro discharge machining of the workpiece by means of the EDM tool manufactured in this way.

According to a development of the preceding embodiment, the attachment of the EDM means has such a shape that it can be used on the one hand in a machine tool for said manufacture of the EDM electrodes and on the other hand in an EDM machine for said manufacture of the

channels by EDM. In this way, the method can be implemented by means of conventional machines for milling and EDM.

According to another development of the preceding embodiment, a plurality of said basic elements are arranged on the EDM means in a path extending around said means before machining, and at least one of said EDM electrodes is machined from each of them in the first operation. By using a plurality of such basic elements, only one of these has to be replaced if one of the EDM electrodes should for any reason become defective during milling thereof or during movement and mounting of the EDM means in the EDM machine.

Another object of the invention is to produce a device which creates possibilities for time-efficient and cost-effective manufacture of a disk-shaped or annular stator component or rotor component. This object is achieved by a device according to claim 12. Further advantageous embodiments of the invention emerge from the following claims and the description.

BRIEF DESCRIPTION OF FIGURES

The invention will be described in greater detail below with reference to the embodiments shown in the accompanying drawings, in which

Figure 1 illustrates a perspective view of an EDM means arranged in a milling machine for milling EDM electrodes;

Figure 2 illustrates a partly cut-away perspective view of the workpiece arranged in an EDM machine, and

Figure 3 illustrates a partly cut-away perspective view of the disk-shaped or annular stator component or rotor component.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

According to an embodiment, the method for manufacturing a stator component or rotor component 1 comprises two stages, namely firstly manufacturing the tool itself which is to be used in subsequent EDM and then electro discharge machining a workpiece 2 by means of the EDM tool manufactured in this way. Here, the manufacture of the EDM tool is carried out by milling.

In electro discharge machining, material is removed from the surface of the workpiece 2 under the action of a power density which arises when short electrical discharges take place between an EDM electrode 6 and the workpiece 2, see Figure 2. The workpiece 2 and the EDM tool are submerged in a dielectric liquid, and voltage is applied, material then being burned away from the workpiece. Here, the EDM tool forms a cathode, and the workpiece forms an anode. Furthermore, the EDM electrode has the shape of a negative replica of the intended shape of the cutout.

Fig. 1 shows a plurality of basic elements 3 arranged in an at least essentially circular path on a top side of a holder element which comprises a disk 4. The basic elements 3 are secured on the disk 4 by screw joints 18. Each of the basic elements 3 has three upwardly projecting portions 5 which are intended to form EDM electrodes 6, see Figure 2. The disk 4 is arranged in a milling machine 7 known per se, and each of the projecting portions 5 is intended to be machined using a milling tool 8. The upwardly projecting portions 5 are arranged at a sufficiently great spacing from one another for it to be possible to reach with the milling tool 8 for the purpose of giving the projecting portions 5 the desired shape.

In a first operation of the method, the EDM electrodes 6 are machined from the basic elements 3 by milling, with a mutual spacing along a circular path. The holder

element comprising the disk 4 and a first machine attachment part 9 located under the disk and connected rigidly thereto form an EDM means intended for an EDM operation following the milling operation. The first machine attachment part 9 is designed so as to be capable of being used both in a milling machine and in an EDM machine. The first machine attachment part 9 is designed so as to fit together with a second machine attachment part 17 of the milling machine. To this end, the first and second machine attachment parts 9, 17 are designed with male and female parts for engagement with one another. The first machine attachment part 9 has three recesses 16 arranged with even spacing in the circumferential direction of the disk 4. The recesses 16 are open in a direction opposite to that side of the disk 4 on which the basic pieces 3 are arranged. The second machine attachment part 17 has three projecting portions 19 for fitting into the recesses 16. In this way, highly accurate centering of the disk 4 is brought about. The projecting portions 19 have the shape of a truncated cone. The EDM means is referred to below using reference number 4. Figure 1 illustrates the basic elements 3 before milling has been started.

In Figure 2, the EDM means 4 is arranged at the top in an EDM machine 10. In relation to Figure 1, the EDM means 4 has been turned through 180° so that the EDM electrodes 6 project downward. According to the embodiment illustrated in Figures 1 and 2, the EDM means 4 has seven basic elements 3 which each have three EDM electrodes 6. In total, there are 21 EDM electrodes. After a reciprocating movement of the EDM means during EDM, 21 cutouts 11 are therefore formed in a workpiece 2. Figure 2 illustrates that the cutouts 11 do not extend through the entire thickness of the disk. The cutouts 11 are intended to form channels 12, see Figure 3. Two adjacent such channels 12 in turn delimit a blade 13. The cutouts 11 extend roughly halfway through the disk.

The EDM machine has a third machine attachment part 20, see Figure 2. The lower part 21 of this is designed for engagement with the recesses 16 and is preferably identical with the second machine attachment part 17 of the milling machine 7 for the purpose of bringing about good centering of the EDM means 4. The third machine attachment part 20 therefore has three cone-shaped projecting portions 22 for engagement with the recesses 16.

In a first EDM stage, a portion (said 21 cutouts 11) of each of a plurality of channels 12 in a first set of channels is therefore machined out of the workpiece 2. The EDM means 4 is then rotated through a number of degrees and then, in a second EDM stage, 21 further cutouts are machined. The EDM operation continues with further rotation of the EDM means followed by further EDM stages until the spacing between two adjacent cutouts 11 in the circumferential direction of the workpiece 2 is essentially the same around the entire workpiece and corresponds to the desired blade thickness.

As can be seen from Figure 2, material is machined away from the workpiece 2 at a spacing from its edge 14 in the radial direction. A portion is therefore retained outside the channels 12. This portion is intended to form a cover 15 for the blades 13 formed subsequently. Figure 2 illustrates the workpiece when the EDM operation from a first flat side thereof has been performed.

The EDM operation continues after the workpiece 2 has been turned, and electro discharge machining is then carried out in the same way from its second flat side. The cutouts from the second side of the workpiece are electro discharge machined out of the workpiece 2 so that they are connected to the cutouts 11 from the

first side, and in this way said channels 12 are formed. The channels 12 will thus extend through the workpiece in the axial direction at a spacing from its edge 14 in the radial direction. The blades 13 are defined between the channels 12 in the circumferential direction of the workpiece.

Each of the EDM electrodes 6 has a shape which corresponds essentially to the shape of the desired channels 12. In order to bring about the desired domed shape of the blades 13, the EDM means 4 is made to perform both a reciprocating movement and a rotary movement in each EDM stage. To be precise, each EDM electrode 6 is guided into the workpiece 2 along a predetermined path. The EDM means 6 is made to perform an oscillating movement when the EDM electrodes have reached their final position in order to produce the desired structure on the channel walls.

Two opposite surfaces of each of the channels in the circumferential direction of the disk are electro discharge machined simultaneously and, to be precise, by the same EDM electrode 6. In other words, the convex surface of one blade and the concave surface of an adjacent blade are electro discharge machined simultaneously.

The machine attachment 9 of the EDM means 4 is designed so that it is possible to use the EDM means 4 both clamped on, in a static position, in a milling machine for machining the EDM electrodes 6 and for rotation in a EDM machine for the purpose of machining the workpiece 2.

The invention is not to be regarded as being limited to the illustrative embodiments described above, but a number of further variants and modifications are conceivable within the scope of the following patent claims.

For example, methods other than milling are possible for manufacturing the EDM tool, for example grinding and wire EDM.

PATENT CLAIMS

1. A method for manufacturing a disk-shaped or annular stator component or rotor component (1) with a plurality of blades (13) arranged one after another in a path extending around said component for guiding a gas flow, characterized in that at least a portion (11) of each of a plurality of channels (12) in a first set of channels is electro discharge machined simultaneously out of a disk-shaped or annular workpiece (2) intended for forming the component (1), which channels (12) are intended to delimit said blades (13) in the circumferential direction of the workpiece.

2. The method as claimed in claim 1, characterized in that, after electro discharge machining said portion (11) of the first set of channels (12), the workpiece (2) is rotated through a distance in its circumferential direction, and then at least a portion of each of a plurality of channels (12) in a second set of channels is electro discharge machined.

3. The method as claimed in claim 1 or 2, characterized in that the workpiece (2) is turned after all the channels have been electro discharge machined from a first side of the same, and in that the remaining portion of the channels (12) is then electro discharge machined in the same way from the second side of the workpiece.

4. The method as claimed in any one of the preceding claims, characterized in that an electrode (6) intended for electro discharge machining is, in the course of its trajectory in the workpiece (2), made to perform simultaneously on the one hand a translatory movement and on the other hand a rotary movement.

5. The method as claimed in any one of the preceding claims, characterized in that two opposite surfaces of each of the channels (12) in the circumferential

direction of the workpiece (2) are electro discharge machined simultaneously.

6. The method as claimed in claim 5, characterized in that the opposite surfaces of each of the channels (12) are electro discharge machined by the same EDM electrode (6).

7. The method as claimed in any one of the preceding claims, characterized in that said channels (12) are electro discharge machined at a spacing from the edge (14) of the workpiece in the radial direction, so that a cover (15) is formed outside the blades in the radial direction and in contact therewith.

8. The method as claimed in any one of the preceding claims, characterized in that, in a first operation, a plurality of EDM electrodes (6) are machined, with a mutual spacing along a curved path, from at least one basic element (3, 5) arranged on a means (4) intended for the electro discharge machining, and in that, in a second operation, the channels (12) are electro discharge machined from the workpiece (2) by means of said EDM electrodes (6).

9. The method as claimed in claim 8, characterized in that the attachment (7) of the EDM means (4) has such a shape that it can be used on the one hand in a machine tool for said manufacture of the EDM electrodes (6) and on the other hand in an EDM machine for said manufacture of the channels (12) by electro discharge machining.

10. The method as claimed in claim 8 or 9, characterized in that a plurality of said basic elements (3, 5) are arranged on the EDM means (4) in a curved path before machining, and in that at least one of said EDM electrodes is machined from each of them in the first operation.

11. The method as claimed in any one of claims 8-10, characterized in that said machining in the first operation comprises milling.

12. A device for manufacturing a disk-shaped or annular stator component or rotor component (1) with a plurality of blades (13) arranged one after another in a path extending around said component for guiding a gas flow, the device comprising an EDM means (4) adapted to be connected to a voltage and to be brought into contact with a workpiece (2) for removal of material from the latter for the purpose of forming one of said blades, characterized in that the EDM means (4) comprises a plurality of EDM electrodes (6) for said contact with the workpiece, which are arranged at a mutual spacing from one another in a curved path in such a way that at least a portion (11) of each of a plurality of channels (12) in a first set of channels can be electro discharge machined simultaneously out of the workpiece (2), which is disk-shaped or annular for forming the component (1), which channels (12) are intended to delimit said blades (13) in the circumferential direction of the workpiece.

13. The device as claimed in claim 12, characterized in that the EDM electrodes (6) are arranged one after another in a path which is at least partly circular.

14. The device as claimed in claim 12 or 13, characterized in that the EDM means (4) comprises a disk and a plurality of basic elements (3) secured on the disk, and in that each of the basic elements comprises a plurality of said EDM electrodes (6).

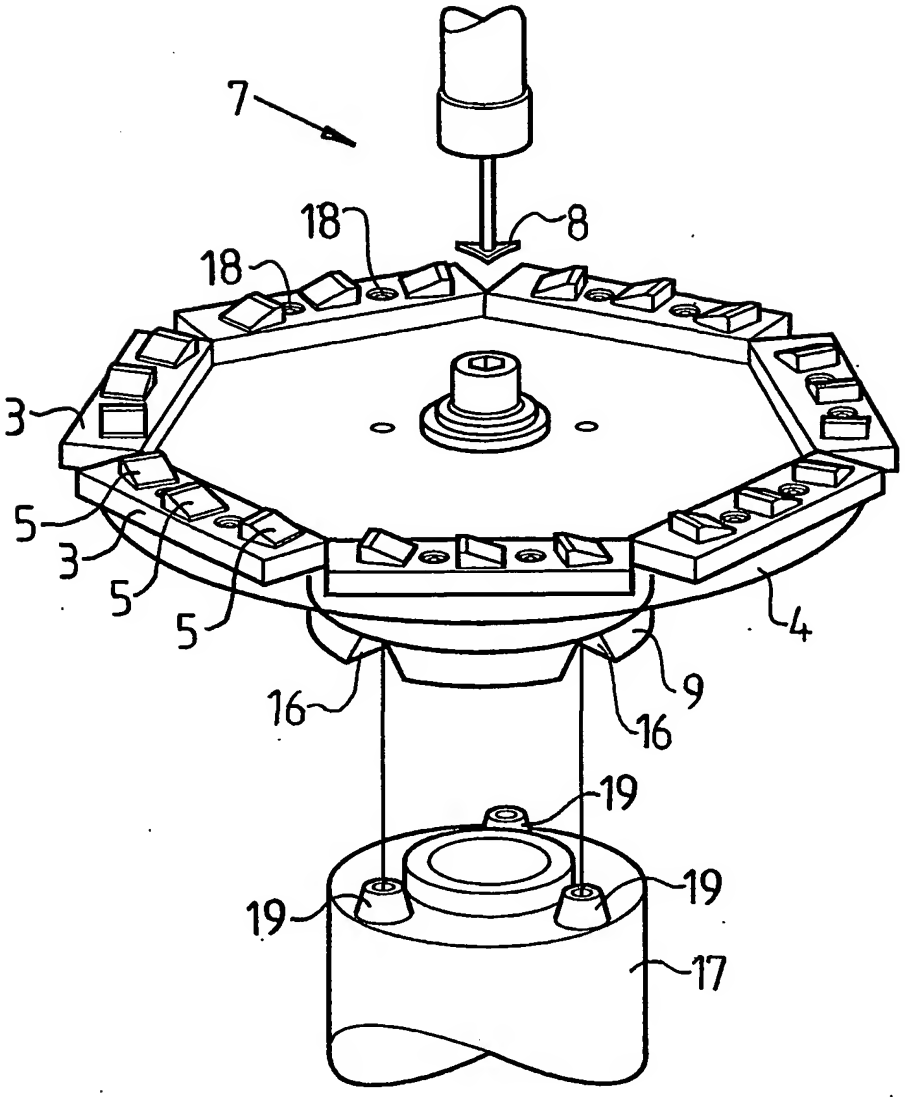

Fig.1

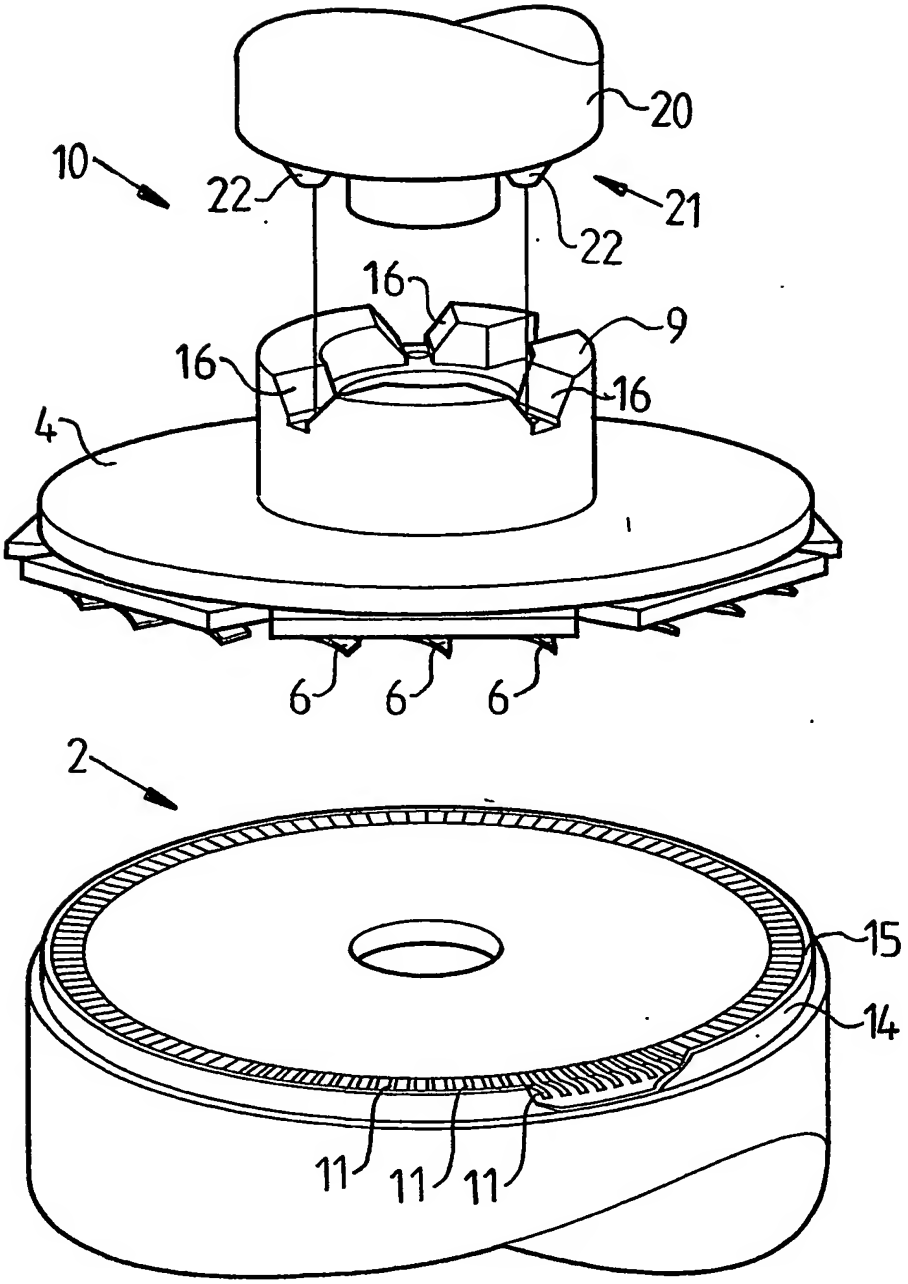

Fig.2

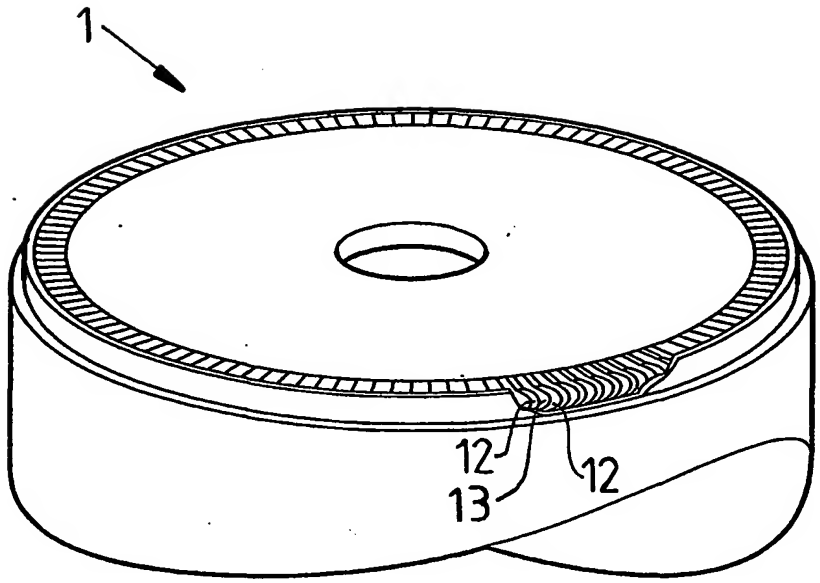

Fig.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00086

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B23H 9/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B23H, B23P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4888863 A (JIMMY A COX ET AL), 26 December 1989 (26.12.89) --	1,12
A	US 5014421 A (M.C. SWARDEN ET AL), 14 May 1991 (14.05.91) -- --------	1,12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 May 2002	13 -05- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Magnus Westöö/MN Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/01/02

International application No.
PCT/SE 02/00086

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4888863 A	26/12/89	CA 1317444 A	11/05/93
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